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Standard Guide for Improved Laboratory Accelerated Tests to Predict the Weathering and for Use in Developing Protocols to Predict the Design Life of Building Sealant Systems[1]

This standard is issued under the fixed designation C1850; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide describes the steps for developing improved laboratory accelerated weathering tests for predicting the natural weathering effects on building sealant systems and for using those tests in development of methods for design life prediction of the systems.

1.2 This guide outlines a systematic approach to development of laboratory accelerated weathering tests of building sealant systems including the identification of needed information, the development of accelerated tests, the application of data, and the reporting of results.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C717 Terminology of Building Seals and Sealants

G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, refer to Terminologies C717 and G113.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *biological degradation factor*—degradation factors directly associated with living organisms, including microorganisms, fungi, and bacteria.

3.2.2 *building sealant system component*—a part of a building sealant system that may include a combination of building materials, such as cladding, substrates or the sealant.

3.2.3 *building sealant system material*—a material that may be used in a building sealant system.

3.2.4 *critical performance characteristic(s)*—a property, or group of properties, of a building sealant system that must be maintained above a certain minimum level.

3.2.5 *degradation mechanism*—the chemical reactions induced in a building component or material by one or more degradation factors resulting in changes in one or more of the critical performance characteristics.

3.2.6 *incompatibility factor*—any of the group of degradation factors that result from detrimental chemical and physical interactions between building components or materials.

3.2.7 *in-service test*—a test in which building components or materials are exposed to degradation factors under in-service conditions.

3.2.8 *performance criterion*—a quantitative statement of a level of properties for a selected characteristic of a component or material needed to ensure compliance with a functional requirement.

3.2.9 *property measurement test*—a test for measuring one or more properties of building components or materials.

3.2.10 *load stress factor*—any degradation factors that result from externally applied sustained or periodic mechanical loads.

3.2.11 *use factor*—any factor that affects the material as a result of the design of the system, installation and maintenance procedures, normal wear and tear, and user abuse. (Example: abrasion of foot traffic.)

3.2.12 *weathering factors*—any degradation factors associated with the natural environment, including radiation, temperature, rain and other forms of water, freezing and thawing.

4. Significance and Use

4.1 This guide is intended to serve as a reference of recommended methodology for users developing relevant, reliable and valid tests for predicting natural weathering effects

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

and for use in developing methods to determine design life of building sealant systems through the use of accelerated test protocols. The proposed standard corrects for some of the deficiencies of existing laboratory accelerated tests of sealants.

4.2 The development of accelerated weathering tests capable of being used in protocols to reliably and accurately predict the long-term in-service performance of building sealant systems have limitations due to:

4.2.1 The external factors that affect functional properties, which are numerous and require effort to quantify, so that many existing accelerated procedures do not include all factors of importance, and

4.2.2 The sealant specimens are often tested in configurations different from those used in-service.

5. Procedure

5.1 This guide describes a recommended sequence of steps for users to follow for developing laboratory accelerated weathering tests for predicting the effects of natural weathering on sealants and for use in development of methods for estimating design life (see Fig. 1 for a flow chart).

6. Scope

6.1 The scope describes the intentions of the test and the degradation factors that should be included.

I–Problem Definition

7. Definition of In-Service Performance Characteristic Requirements and Criteria

7.1 The critical performance characteristic criteria define the minimum acceptable levels of in-service functional properties stated in terms of absolute values or changes from the initial test.

8. Characterization of the Sealant

8.1 Characterize the sealant system in terms of composition, critical performance characteristics, and physical properties the

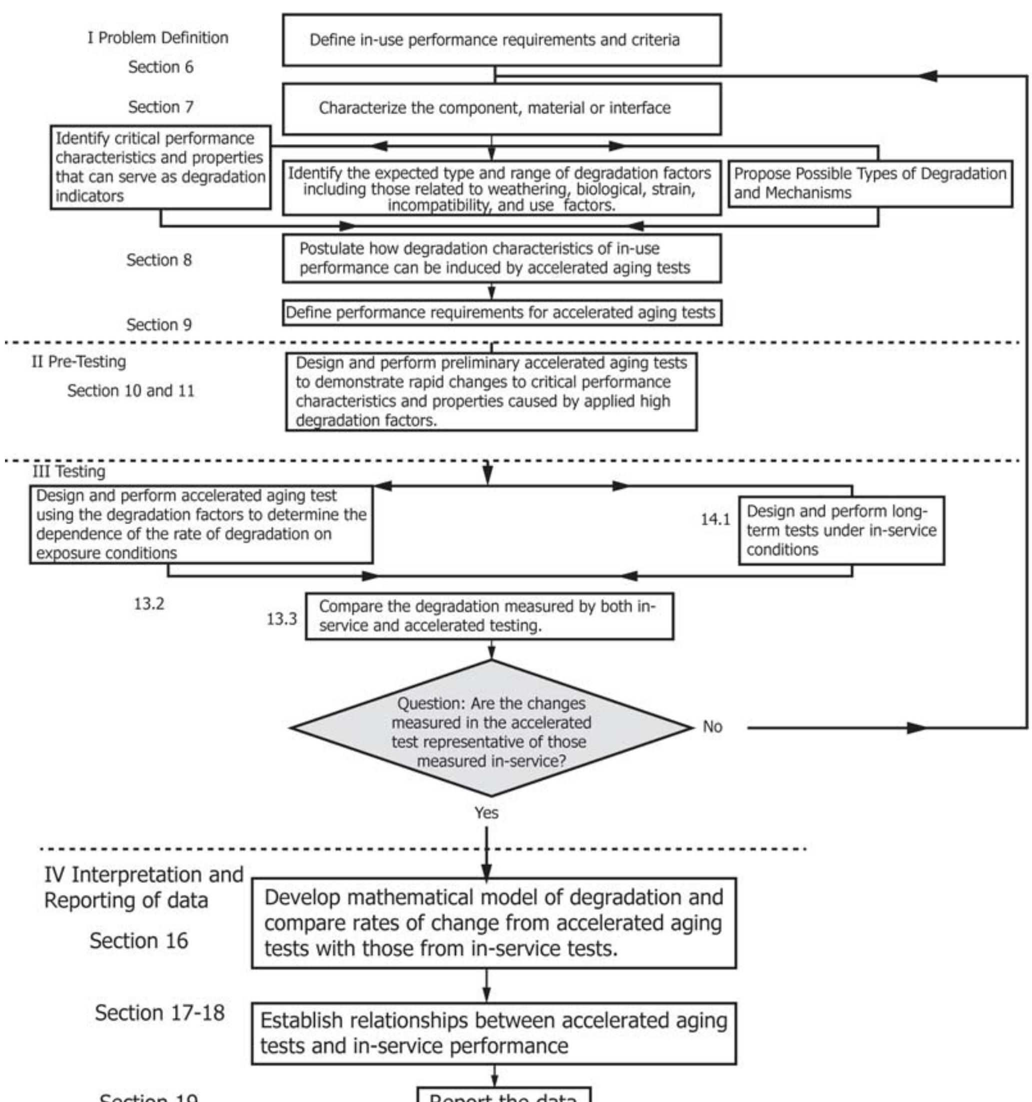

FIG. 1 Recommended Steps for Developing Improved Artificial Accelerated Weathering Tests to Predict Natural Weathering Effects and for Use in Developing Protocols for Predicting Design Life

changes of which will serve as degradation indicators, the range and type of degradation factors to which the sealant responds, and all possible types of degradation and mechanisms by which the degradation factors induce changes in the critical performance properties.

8.1.1 *Critical Performance Characteristics and Properties:*

8.1.1.1 Properties used as measures of degradation must be the same as or directly linked to the critical performance characteristic. Fig. 2 provides a matrix for use in identifying properties that indicate degradation.

8.1.1.2 *The Vertical Axis of the Matrix*—An alphabetical letter is used in the matrix to designate individual building elements and interfaces as part of a building sealant system. For example, a wall element may include an exterior coating (A), an exterior substrate (B), a structural member (C), insulation (D), an interior substrate (E), and an interior coating (F). The interfaces between each pair of materials can then be designated, for example, A-B, B-C, A-C, etc.

8.1.1.3 Consider the characteristics of the sealant and interfaces with other building components in the evaluation. Fig. 2 lists changes in properties that may be useful as measures of degradation. These include both visual changes (chalking, crazing, cracking, checking, flaking, scaling, blistering) and instrumentally measurable changes (color, gloss, tensile modulus, etc.).

8.1.2 *Type and Range of Degradation Factors:*

8.1.2.1 Identify the type of degradation factors to which the sealant will be exposed in-service and their range. A list of common degradation factors is presented in Table 1. This list is not exhaustive and other possible important factors should be sought in each specific case.

8.1.2.2 Quantitative information on weathering factors is available from published weather and climatological data. These data will usually be sufficient to indicate the ranges of intensities to which the component or material will be exposed in-service.

8.1.2.3 Stress factors consist of sustained stress, developed from seasonal changes, and periodic stress, such as daily temperature or moisture variation. The intensities of stress factors can be estimated.

8.1.2.4 *Chemical and Physical Incompatibility between Dissimilar Materials*—This includes stress caused by the different thermal expansion coefficients of rigidly connected dissimilar materials that can be estimated.

8.1.2.5 Use factors include the design of the system, installation and maintenance procedures, normal wear and tear and abuse.

8.1.2.6 Biological, incompatibility, and use factors and their range of in-service intensity can be difficult to quantify but upper limits of common in-service conditions can usually be estimated from a technical assessment and engineering judgment. Consider each of the degradation factors that the sealant may experience in-service within the given building system in designing the assessment protocol.

TABLE 1 Degradation Factors Affecting the Design Life of Sealant Systems

Weathering Factors
Radiation Solar Nuclear Thermal
Temperature Cycles
Water
Solid (such as snow, ice)
Liquid (such as rain, condensation, standing water)
Vapor (such as high relative humidity)
Mechanical Movements
Normal Air Constituents Oxygen and ozone Carbon dioxide
Air Contaminants
Gases (such as oxides of nitrogen and sulfur)
Mists (such as aerosols, salt, acids, and alkalies dissolved in water)
Particulates (such as sand, dust, dirt)
Freeze-thaw
Wind
Biological Factors Microorganisms Fungi
Bacteria
Strain
Static strain of seasonal cycles
Dynamic strain of daily cycles
Stress Factors, sustained or periodic
Physical action of water, as rain, hail, sleet, and snow
Physical action of wind
Combination of physical action of water and wind
Movement due to other factors
Incompatibility Factors
Chemical
Physical
Use Factors
Design of system
Installation and maintenance procedures
Normal wear and tear
Abuse by the user

Observable Change	Visual Inspection											Measured Change																												
Building Element	Micro-organisms growth	General appearance	Chalking	Crazing	Cracking	Checking	Flaking	Scaling	Blistering	Efflorescence	Rupture	Color	Gloss	Reflectance	Haze	Texture	Transparency	Abrasion resistance	Hardness	Washability	surface wettability	Water absorption	Vapor permeance	Dimensions	Thermal properties	Electrical properties	Creep rupture	Creep deformation	Peel strength	Flexural strength	Tear strength	Impact resistance	Fatigue strength	Tensile strength	Compressive strength	Shear strength	Tensile modulus	Compressive modulus	Shear modulus	Adhesion
A																																								
A-B																																								
B																																								
B-C																																								
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FIG. 2 Example of a Matrix for Identifying Observable Changes of Sealants

8.1.3 *Postulation of Types of Degradation*—This step of the characterization procedure requires the user to propose possible types of degradation by which the identified degradation factors can induce changes in the critical performance properties of the sealant system.

9. Postulations Regarding Accelerated Aging Tests

9.1 Once the information from Sections 7 and 8 has been obtained, postulations are made regarding specific procedures for accelerating the degradation using the identified degradation factors. For example, if thermal degradation is identified as a possible degradation factor then it may be postulated that this type of factor can be accelerated by exposure to temperatures higher than those expected in-service. Users are cautioned that applying extreme levels of stress to accelerate the rate of degradation may activate mechanisms and induce changes that are not predictive of in-service degradation. The postulates that are made in this step lay the groundwork for designing preliminary accelerated tests.

10. Definition of Performance Requirements

10.1 Define performance requirements of the sealant. The performance statements should be qualitative summaries of the information obtained in Sections 8 and 9 that describe the intention of the test.

II–Pre-Testing

11. Scope:

11.1 Pre-testing contributes to the user knowledge of the primary degradation factors leading to property changes It can be used to show that rapid changes in the properties of the sealant can be induced by exposure to high levels of the degradation factors. Information obtained from pre-testing includes indications of *(1)* property changes that are likely to be useful as degradation indicators, *(2)* the order of importance of the degradation factors, *(3)* the intensities of degradation factors needed to induce rapid property changes.

12. Design of Pre-Tests

12.1 Pre-tests should be designed based on the information obtained in Sections 8, 9, and 10. The tests should provide for various properties to be measured before and after exposure testing to determine which properties provide the most reliable and consistent degradation indicators. Also, evaluate the degradation factors identified in Section 8, to which the building sealant system will be exposed in-service, to determine the most important factors.

12.2 The intensity of weathering and other stress factors used in pre-tests can be used in accordance with the quantitative ranges identified in Section 8. Weather and climatological data for the most extreme climates in which the sealant may be used normally form the basis for the intensities of these factors in the pre-tests. Calculated sustained stress and periodic stress can be used.

12.3 Biological and incompatibility factors may not be important unless combined with high levels of weathering factors. For example, fungi and bacteria are most active in warm, moist locations; chemical incompatibility may only be important as long as liquid water is present between the joined materials; physical incompatibility may not be important unless there are large temperature changes. The effects of incompatibility factors can, therefore, usually be evaluated along with tests to determine the effect of weathering factors.

12.4 Use factors are not usually included in accelerated aging tests. Installation and maintenance practices are assumed to be provided as recommended by the manufacturer, and intentional abuse is usually considered to be beyond the scope of test methods. Although use factors are not often included in accelerated aging tests, they can affect the sealant functional life and should be evaluated if deemed critical.

III–Testing

13. Scope

13.1 The purposes of this procedure are to design and conduct new or improved accelerated tests to determine the relationships between the degradation rates and the exposure conditions; to design and perform tests under in-service conditions to confirm that the types of degradation induced by accelerated aging tests are similar to those observed in-service; and to measure the rates at which properties change in-service.

14. Design of Tests

14.1 *Long-term In-Service Tests*—Long-term in-service tests are necessary to validate the degradation factors of importance for the sealant. These tests may be actual in-service tests of a model or mock-up system or exposure of selected materials at outdoor weathering sites. It is essential to design the in-service tests so that all factors of importance are considered. Where possible, the tests should permit the most important type of degradation to be identified in a relatively short period of time; however, information obtained during longer exposures is also needed to aid in relating the rates of change in laboratory tests to those in the in-service tests. The intensity or magnitude of the degradation factors should be measured during the tests

14.2 *Laboratory Accelerated Tests:*

14.2.1 The goal of laboratory accelerated testing is to provide a relatively rapid means of measuring the rate of property changes typical of those that occur in long-term in-service use. These tests should normally be designed from information obtained in pre-tests. In general, the intensity of degradation factors in these tests will be less than in the pre-tests to reduce the likelihood of causing degradation by mechanisms that do not occur in-service. The properties measured before and after testing should be those that have been identified as directly related to the sealant's critical performance characteristics. All important degradation factors should be included in the exposure conditions.

14.2.2 The potential of synergism should always be borne in mind in the development of accelerated tests. For example, the combined effects of weathering factors, such as solar radiation, temperature, applied strain and moisture, may be greater than the sum of the effects of the individual factors. The intensity or magnitude of the degradation factors in the accelerated aging test should be measured to aid in determining the effects of increased intensity and in relating the rates of change in the in-service and accelerated aging tests.

14.3 *Comparison of Types of Degradation*—Compare the types of degradation obtained in the accelerated aging tests and in the in-service tests. If the initial accelerated tests do not induce types of degradation representative of in-service degradation, alter the design of the accelerated tests taking into account the information obtained in Parts I and II (see loop in Fig. 1).

IV–Application of Data and Reporting of Conclusions

15. Scope

15.1 This procedure covers application of the data and reporting of results of procedures in Parts I, II, and III. The applications include *(1)* estimation of design life based on comparison of rates of change in the laboratory accelerated test versus the in-service test, and *(2)* comparison of the relative durability of a number of sealants.

16. Development of Mathematical Models for Comparing Rates of Changes

16.1 After establishing that the type of degradation induced by the accelerated tests are the same as those observed in-service, compare the rates of change of properties in the two tests. For the simplest case, where degradation proceeds at a constant rate, determine the acceleration factor, K, as follows:

$$K = R_{AT}/R \tag{1}$$

where:

R_{AT} = rate of change obtained from the accelerated aging test, and

R_{LT} = rate of change obtained from the long-term in-service test.

16.1.1 However, the relationship between the results of the two tests is seldom as simple. For nonlinear relationships, mathematical modeling may be necessary to establish a satisfactory relationship between the rates of change. Such models must be able to process quantitative data about the degradation factors in calculations of the rate of change during the test period.

17. Definition of Performance Criteria for Estimating Design Life

17.1 User performance criteria that define quantitative minimum acceptable levels of performance.

18. Estimates of Design Life or Comparison of Relative Durabilities

18.1 The expected design life of the sealant can be estimated based on the information in Section 16 for comparing the rates of change in the laboratory accelerated and the in-service tests. However, this method has several limitations: *(1)* It is not applicable to sealants that have long term resistance to weathering because changes to properties under in-service conditions must be measurable within a reasonable exposure time, and *(2)* the relative rates of change by the two types of tests may depend on the stage of degradation of the sealant. The rates should be compared when the degradation is at the same stage in each of the tests, but the relative rates can change with progression of degradation. Therefore, studies are required to verify the applicability of the method for different types of sealants. An alternative to estimating design life is to compare the relative degradation rates of a number of components or materials that have been tested in a similar manner. Such comparisons are often made to rank components or materials in terms of expected long-term performance.

19. Report of Data

19.1 A report summarizing the findings of the analysis in Parts I, II, III, and IV should be prepared. The report is particularly important to others who attempt to use the tests or understand the rationale for procedures or assumptions. For this reason, state assumptions made and give reference to works that have directly affected decisions. It is suggested that the report include the elements described in Parts I, II, III, and IV.